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(Selected Articles)

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Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
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К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

FOLLOWING ARE THE CORRESPONDING RUSSIAN AND ENGLISH DESIGNATIONS OF THE TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}
rot	curl
lg	log

INVESTIGATION OF STATIC FRICTION OF CAPRONE ON STEEL AT DIFFERENT TEMPERATURES

D. T. Avdeyev and O. P. Kireyev

More precise determination of a series of mechanisms working under conditions of a change of ambient temperature requires knowledge of the dependence of the coefficient of static friction on temperature. In order to determine qualitative and quantitative influence of the ambient temperature on static friction of certain frictional pairs, experiments were conducted on a specially designed installation, shown on Fig. 1. Annular sample 12 was set in upper mount 9, connected by a double key connection with bushing 10, which together with turning sector 11 could turn in radial bearings. Counterbody 15 was fixed in lower mount 14, resting on a thrust ballbearing and self-adjusting with the help of spherical support 17. The friction pair was in chamber 18, in the wall of which was a built-in electrospiral. Temperature in the chamber was changed by voltage regulator 13 and controlled by thermocouple. Normal force was created by load 1 and through levers 2, 3, and the upper thrust bearing acted on mount 9. Shear force was created by the weight of the fraction passed from vessel 5 into load container 16, connected by cable with the turning sector. After touching the sample the mount was turned and container 16 was lowered. Lever 7 is turned and under the action of spring 6 bolt 8 covered the hole of the exit channel of the vessel. Weighing then the container with the fraction in it, the shear force of friction was determined.

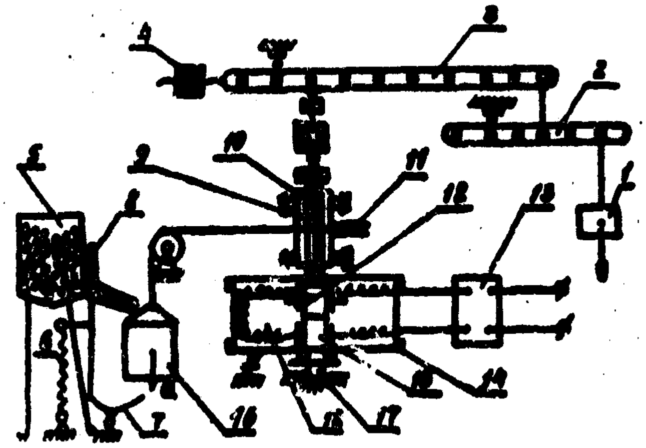

Fig. 1.

Experiments were conducted for steel-steel and steel-caprone pairs secondary in TU-V-75-61, where the counterbody was steel ST 6. This selection is explained by the fact that comparison of temperature characteristics of static friction of such different materials as steel and caprone is of great interest. Cleanness of the contact surfaces was identical and equaled ∇6, which was achieved by grinding. Specific pressure on the contact surfaces amounted to 10 kgf/cm^2. Before experiments the working surfaces were thoroughly washed in acetone. It was possible to exclude the influence of boundary lubricating layers and to set the experiment under conditions "of dry friction."

Each experiment was conducted in the following way. Temperature in the chamber rose to the required value. Samples were put into contact and held during five minutes under load at the rated temperature. Then the specimens were touched and the container with the fraction were weighed. The friction in the bearings of mount 9 depending upon temperature was preliminarily determined and considered during treatment of experimental data. For every pair of samples at the rated temperature three experiments each were conducted in the interval from 40 to 140°C. The coefficient of friction in every experiment was calculated by the formula [1]:

$$f = \frac{3R}{2P} \cdot \frac{r_2^2 - r_1^2}{r_2^3 - r_1^3} Q.$$

where R - radius of turning sector, P - weight of load, r_1 - internal radius of sample, r_2 - external radius of sample, Q - weight of container with fraction.

Results of experiments are shown on the graph (Fig. 2). Every point of the curve is the arithmetic mean of results of nine experiments. By analyzing the graph, it may be concluded that in the investigated interval of temperatures the coefficient of static friction increased with an increase of temperature for the steel-steel pair (curve 1). This phenomenon can be explained by the constant increase of oxide film on the contact surfaces. It is known that there is a certain optimum thickness of the film, at which it has the most strength and maximum adhesion to metal [2, 3]. Obviously, the thickness of the oxide film under conditions of the experiment did not exceed this level.

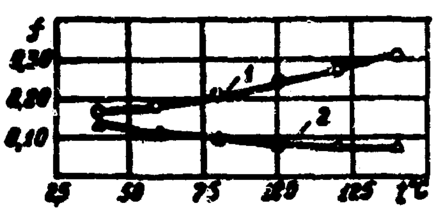

Fig. 2.

The drop of the coefficient of static friction for the steel-caprone pair (curve 2) can be explained by the fact that for caprone, as a more plastic material, the predominant phenomenon in static friction will be molecular interaction. With an increase of temperature the adhesive bonds weaken and the coefficient of friction decreases [5, 6].

Conclusions

1. Good reproducibility of experiments and comparatively small spread of points indicate that the design considers basic factors affecting static friction.

2. With an increase of temperature increase of the coefficient of static friction for a steel-steel pair is observed.

3. The coefficient of static friction for a steel-caprone pair decreases with a temperature rise.

4. The increase of the coefficient of static friction for a steel-steel pair can be explained by a growth of oxide film on the friction surface, lowering the coefficient of static friction for a steel-caprone pair by adhesive interaction.

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STRUCTURE AND ANTIFRICTION PROPERTIES OF LOW-PRESSURE POLYETHYLENE DEPENDING ON TWO METHODS OF MIXING WITH MINERAL OIL

Yu. P. Makhin and A. A. Kut'kov

Recently there appeared a new branch of polymer science - structural mechanics, which makes it possible to obtain new materials by a change of the supra-molecular structures of existing polymers. This branch of polymer science uses principles of plasticization to create the new polymer materials with a preassigned complex of physical and mechanical properties.

The plasticizers are low-molecular substances, which are introduced in a polymer to increase mobility of their structural elements and to change in a desirable direction the physical and mechanical properties of the polymer. A common property of all plasticizers is that, exerting are influence on high-molecular compounds, they do not go into chemical reaction with them and are held in the polymer throughout the time of its existence [1, 2, 3]. Investigations of Soviet scientists [2, 4, 5] established that the most important feature of solid polymeric bodies is the variety of supra-molecular structures formed from packs of macromolecules.

In accordance with the contemporary idea about the structure of polymers, plasticization can be divided into two forms: molecular (intrabundle) and structural (interbundle). The basis of this separation is the accepted character of distribution of plasticizer in a

polymer taking into account the forming supra-molecular structures of plasticized polymer. In the first case the plasticizer should be distributed very evenly among the chain molecules of the polymer; there is a destruction of its supra-molecular structures – the plasticizer dissolves the polymer. In the second case molecules of plasticizer are distributed among supra-molecular formations; the interaction of molecules of plasticizer with active groups of polymer chains is so weakened that it is limited only to molecules of the polymer distributed on the surface of the supra-molecular structural formations [2, 3].

At present plasticization is applied basically to amorphous polymers, but questions of plasticization of crystal polymers are in the stage of investigations. In connection with the ever greater significance which crystal polymers obtain in industry, in particular polyethylene, the influence of plasticization on its structure and antifriction properties presents special interest. It is possible to assume that a definite influence on structure and antifriction properties of polyethylene will be rendered also by combining it with a plasticizer. Here we describe experiments checking this assumption.

Samples for investigation were pressed in a special casting setup placed on a hydraulic press (Fig. 1). This made it possible to obtain samples at a constant specific pressure of 20 kgf/cm^2. The installation consisted of lower plate 1 and upper plate 16, connected by four stands 14 and bolts 15. To the upper plate was welded heating cylinder 12, which produced uniform heating and melting of the polymer. From the heating cylinder the mass was pressed by plunger 13 through injector 10 into a packet of sieves, consisting of housing into which bronze grids were inserted, draw plate 8 and spacer ring 7. The packet of sieves served to split the finely-dispersed particles of polyethylene and thoroughly mixed their mineral oil. The mass falls into 5, closed from below by piston 4. Heating cylinder, torpedo and form were pressed by tightening screw 3, which was screwed into bushing 2. Cylinder and torpedo were heated by electricity, temperature was controlled by a thermocouple and galvanometer; specimens were pressed

at 140°C. After pressing, samples were air-cooled in the form at 3 deg/min. Ready samples were 25 mm (diam) × 60 mm (height).

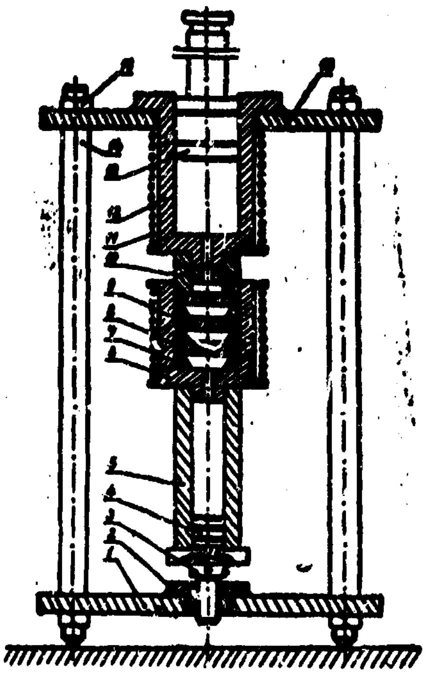

Fig. 1.

The initial mass for pressing was a mixture of polymer material and plasticizer. The polymer was low-pressure (l.p.) polyethylene in the form of finely-dispersed powder, and the plasticizer was spindle oil. The construction of the installation allowed pressing samples by two methods. In the first method the initial mass was covered in the heating cylinder, heated, held to full melting and directly from the cylinder pressed into the form. In this case oil enveloped particles of polyethylene both before the material melted and afterward, not disturbing the entirety of the particles. In the second method of pressing the melted mass from the heating cylinder passed through a packet of sieves, was thoroughly mixed and only after that pressed into the form.

Structure of the samples was investigated by X-ray. Samples for roentgenographic study had the following composition: No. 1 – pure l.p. polyethylene; No. 2 – plasticized l.p. polyethylene, obtained by the first method: 50% finely-dispersed powder of l.p. polyethylene and 50% spindle oil; No. 3 – plasticized l.p. polyethylene, obtained by the second method: 50% finely-dispersed powder of l.p. polyethylene and 50% spindle oil.

The X-ray photographs were taken on a URS-50I diffractometer. Treatment of X-ray photographs and comparison of results permitted determining the degree of crystallinity for samples of pure polyethylene (75-80%) (Fig. 2). For samples of plasticized l.p. polyethylene obtained by the first method the crystal phase composes 75-80% (Fig. 3). For samples of plasticized l.p. polyethylene obtained by the second method the crystal phase composes 25-30% (Fig. 4).

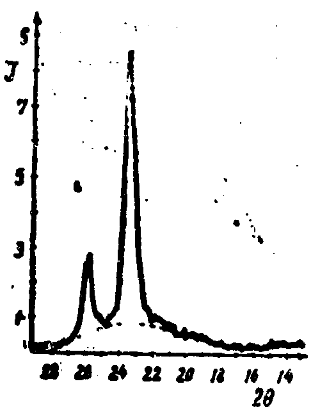

Fig. 2.

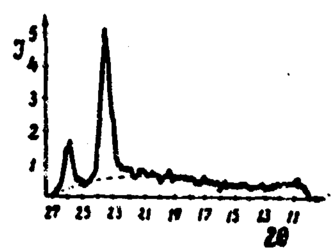

Fig. 3.

Fig. 4.

In obtaining samples by the first method the degree of crystallinity of l.p. polyethylene does not drop as compared to pure polyethylene. In obtaining samples by the second method the degree of crystallinity essentially drops. Apparently, in this case mineral oil destroys the crystal structure of the l.p. polyethylene. Thus, X-ray study showed that in the plasticizing of samples of polyethylene by the first method, the compatibility of polymer with mineral oil is very low, and in the second method the compatibility essentially increases.

To study supra-molecular structures of plasticized polyethylene in order to show the relative position of polymer and plasticizer in a system, methods of optical microscopy were used. Methods of fine cuts and brittle fracture showed that samples of plasticized polyethylene obtained by the first method have a space structural frame of polyethylene, in the free cavities of which is plasticizer (spindle oil). For samples obtained by the second method uniform structure is observed. These investigatings confirm the fact that for samples of plasticized l.p. polyethylene obtained by the first method, the compatibility of polymer and plasticizer is very low, and for samples obtained by the second method very high.

Thus, the first method of combination makes it possible to obtain a specific "honeycomb" structure of polyethylene. Such plasticization is conditionally called "macrostructure" plasticization. For samples of polyethylene prepared by the second method molecular (intrabundle) plasticization is obtained. In this case, thanks to the thorough mixing of polyethylene in the melted state with oil, there is good combination. Molecules of oil are evenly distributed between molecules of polyethylene, and as a result a solution is obtained.

Investigations of antifriction properties were conducted on a friction setup, which was made up of a friction gage with a constant contact rate of the samples - 15 mm/min. Specific pressure on samples in all experiments was 3 kgf/cm^2. The resistance of the samples to a shift was measured with resistance pickups glued on an elastic beam, and an EPP-09 electronic potentiometer. The counterbody for the

investigation of antifriction properties of plasticized polyethylene was steel plate with a cleanness of treatment of ∇6.

Results of the investigations are represented on Fig. 5. Curve 1 shows the change of coefficients of friction of l.p. polyethylene during molecular plasticization depending upon the percent of plasticizer, curve 2 – change of coefficients of friction of l.p. polyethylene during macrostructural plasticization also depending upon the percent of plasticizer.

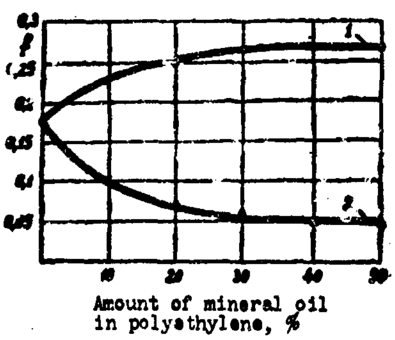

Fig. 5.

Molecular (intrabundle) plasticization of polyethylene leads to impairment of its antifriction properties. With an increase of the percent of spindle oil the coefficients of friction increase. It was established that with an increase of the amount of spindle oil to 30% in the polyethylene occurs a smooth growth of coefficients, and with a further increase of oil the coefficients of friction stabilize.

"Macrostructural" plasticization of polyethylene leads to a drop of the coefficients of friction. The greatest drop of coefficients of friction is observed at 50% spindle oil in l.p. polyethylene. In this case the coefficient of friction reaches 0.05. With a further increase of the percent of plasticizer the coefficients of friction fall insignificantly, but there is an impairment of physical and mechanical properties of the material.

Conclusions

1. With the thorough mixing of polyethylene and mineral oil in the melted state molecular plasticization is obtained and uniform structural is observed. However, the crystal phase essentially decreases as compared to the crystal phase of pure polyethylene.

2. In the case of a combination of polyethylene with mineral oil without mixing in the melted state, a honeycomb structure is obtained, in which the polyethylene serves as the basis for the structural frame. The quantity of crystal phase remains constant as for pure polyethylene.

3. In molecular plasticization of polyethylene by mineral oil the antifriction properties of the polymer fell off with an increase of the percent of oil.

4. In "macrostructural" plasticization of polyethylene by mineral oil the antifriction properties of the polymer improve with an increase of the percent of oil.

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INVESTIGATION OF THE STATIC FRICTION OF CAPRONE ON STEEL AT GREAT UNIT PRESSURES IN WATER AND WHEN DRY

A. I. Romanovskiy

Many mechanisms and machine units works alternately in water and in air, such as ship raisers, hydraulic locks in sluices and spillways, different mechanisms in irrigating systems, and also units and mechanisms, working under the open sky. Static friction under great specific pressures in water and during drying has been studied little.

Certain researchers have long noted unusual phenomena occurring when water falls on a friction surface [1-6].

Recently all more frequently for friction assemblies working water different plastics, in particular, caprone, have been used. Usually caprone is used in a pair with steel.

The purpose of this work has the investigation of static friction of a steel-caprone in water and during drying. Furthermore, it was interesting to clarify the influence on friction of abrasive, contained usually in water, and also remaining on the steel surfaces after grinding.

Experiments were conducted on an end-type machine [7], which allowed obtaining high and constant pressure in contact, and also changing the rate of application of the tangential force according to its size during the experiment.

One sample was steel 45 ($H_Б$ = 187), the other was caprone B. Since specific pressures in the friction contact of assemblies is rather high (200-250 kgf/cm^2), the specific pressure in all experiments was taken as 208 kgf/cm^2. Surface cleanness for all samples was ∇6. Ambient temperature was approximately constant from 20 to 23°C, and relative atmospheric humidity was 50-52%. Every pair of samples was tested 320 min. This duration is explained by the fact that under experimental conditions the samples were completely dried in 300 min.

The rate of loading in all experiments was constant and 0.5 kgf/s. In all there were eight series of experiments. In every series 5 pair of samples was investigated, and with every pair 64 experiments were conducted with an interval of 5 min.

In the first series of experiments both samples were cut on a lathe on open air. In this case the coefficient of friction was stable (0.21-0.24). The spread of points did not exceed 5-6% of the average value for every pair of samples (Fig. 1, curve 1).

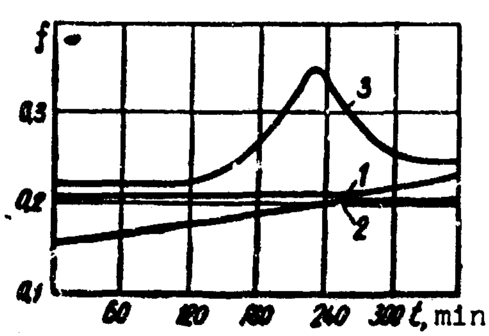

Fig. 1.

In experiments of the second series samples also sharpened on a lathe, but during grinding they were amply watered with tap water of an overall hardness of 16, 23°N. The coefficient of friction as the samples dried somewhat increased (from 0.15-0.21), remaining then constant (Fig. 1, curve 2).

In the third series of experiments the caprone sample was sharpened on a machine, and the steel sample after grinding was additional treated with emery sandpaper No. 30, after which it was thoroughly washed by water and dried. The coefficient of friction in this case remained stable (Fig. 2, curve 8).

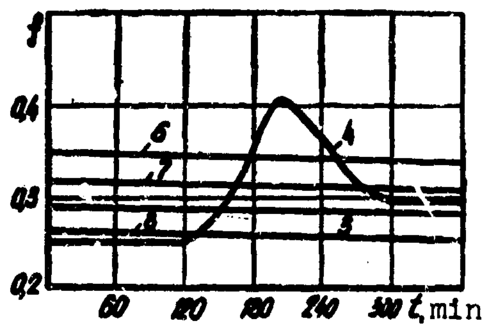

Fig. 2.

In the fourth series of experiments samples were prepared just as in the third series of experiments, only during their grinding they were wetted and before setting in the machine they were moistened by water. In this case a considerable change of the coefficient of friction during drying was noted (Fig. 1, curve 3). In the first 120 min the coefficient of friction was low (0.22), then it slowly increased and after 220 min reached maximum (0.35); after that it comparatively rapidly decreased. After 300 min it reached 0.25 and thereafter remained constant.

In the fifth series of experiments the friction surface of the caprone sample was sharpened; on the steel after grinding a layer of glass powder was deposited. Dimensions of the particles of powder were within limits of 0.5 µm. The filling of the nominal friction surface of the sample by the powder in some cases composed 20%, in other cases 40%. The difference in filling did not affect the change of the coefficient of friction during drying, but acted only on its absolute value.

In this case, as in the preceding, the coefficient of friction considerably changed during drying (Fig. 2, curve 4). In the first 120 min it was 0.25-0.26, after 200 min 0.40-0.41 and after 300 min it descended to 0.3, remaining then constant.

In the sixth series of experiments samples were prepared analogously to experiments of the fifth series, only in the friction zone iron powder was introduced (iron reduced in hydrogen) of approximately the same granularity. This time the coefficient of friction insignificantly changed, slightly dropping from 0.3 to 0.28 during the drying of water (Fig. 2, curve 5).

In the seventh and eighth series of experiments samples were turned on a lathe; on the dry friction surfaces in one case glass (Fig. 2, curve 6), and in the other iron (Fig. 2, curve 7) powders of the same granularity were deposited. In both cases the coefficient of friction changed insignificantly, somewhat dropping with time.

It is necessary to note that in all series of experiments when the samples were prepared the chuck of the lathe, cutter and samples were thoroughly degreased by acetone.

By analyzing the data of the experiments, we can note one characteristic peculiarity. With clean friction surfaces (considered to be the absence of abrasive) the coefficient of static friction of dry samples and those moistened by water with time remains constant. If in the friction zone there is current-conducting powder (iron) both dry and in combination with water the coefficient of friction insignificantly changes in time. In dry friction with glass powder the coefficient of friction also changes little in time. Only the combination of a dielectric powder (glass powder or abrasive particles after treatment by emery sandpaper) with water in the friction zone considerably affects the coefficient of static friction in the drying of water.

We explain the small coefficient of friction in the initial period of the experiment for samples whose friction surface of which was covered by glass powder or treated with emery sandpaper, by the presence of a colloidal film formed by highly-dispersed particles of abrasive or glass in combination with water and dividing the friction surface. The presence of abrasive particles on the surface of the metal even after thorough washing was noticeable under a microscope (640 times). When there is an excess of water the viscosity of the colloidal film is small because of the comparatively low initial friction. With the evaporation of water viscosity of the colloidal film increases, which in turn leads to an increase of frictional force. The formation of a colloidal film probably is promoted by charges of static electricity, which can be concentrated on particles of the dielectric (glass and abrasive). In the electrical field of these charges weakly polarized molecules of water can be oriented. Water in this case becomes to a certain degree polar-active to particles of glass and abrasive. This is mentioned in work [2]. In experiments with iron powder, particles of which conduct current, a colloidal film will not form. Only the abrasive action of powder has an effect, and therefore the coefficient of friction remains almost constant

The increase of the coefficient of friction in the second region of the curve (Fig. 1, curve 3) can be explained on one hand by the increase of viscosity of the colloidal film with drying of water and the phenomenon of seizing (concretization), occurring apparently during the drying of the water, on the other hand. The phenomenon of seizing is confirmed by the comparatively fast fall of the coefficient of friction after the drying of the water. Frictional connections, caused by the seizing (concretization) after their destruction at the instant of touching cannot be formed again in the absence of water.

Seizing possibly was observed in experiments [2]: a high coefficient of friction was obtained at the first touching of samples, dried after wetting by warm dry air; in subsequent touchings of these samples the coefficient of friction also dropped rapidly.

The authors conducted similar investigations for steel samples [7].

Comparing results of experiments on the friction of steel samples and steel on caprone, it is possible to note the following. The coefficient of friction of steel samples treated by emery sandpaper changes during drying more sharply (from 0.1 to 0.27) than during the friction of steel on caprone (from 0.22 to 0.35). In the first case the coefficient of friction changed by almost three times, and in the second by only 1.5 times. This circumstance is very important for friction assemblies in hydraulic engineering constructions. Since the coefficient of friction during drying is stabler for a steel-caprone pair the creation of materials in the form of compositions on a plastic base with a low and sufficiently stable coefficient of friction for work in water and during drying is desirable.

Conclusions

1. The presence of water in the case of friction of clean surfaces of steel and caprone essentially does not affect static friction.

2. The presence of current-conducting powders (iron) in the zone of friction insignificantly influences the change of the coefficient of friction during drying.

3. The presence of dielectric powders (glass, abrasive) in the zone of friction in combination with water strongly affects the change of the coefficient of static friction during drying.

4. The considerable increase of coefficient of friction when the water dries up can be explained by the phenomenon of seizing (concretization).

5. Inasmuch as the static friction of a steel-caprone pair with abrasive during drying changes less than in the case of steel on steel, one should recommend the use of caprone or compositions on its base for friction assemblies of hydraulic constructions.

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THE INVESTIGATION OF GRAPHITOPLAST FOR FRICTION AND WEAR IN LUBRICATION WITH WATER

V. N. Kruzhilin

Graphite antifriction materials possess an extremely favorable combination of properties, making it possible to use them in machine building, in particular, in the operation of face packings in pumps. The use of graphitoplast being a composition of graphite and phenol-formaldehyde resin in friction pairs is expedient, since in contrast to other graphite materials it is cheap and the technology of its manufacture is simple.

During operation there were determined the coefficients of friction and wear of graphitoplast with respect to certain silico-organic plastics in lubrication with tap water.

Tests were conducted on a friction machine (Fig. 1) consisting of three main units: a loading device (with drive), a friction unit and a device for measuring frictional force. The loading device consists of a lever system with loads 4 and spindle 1, on which is screwed holder 2 with graphite sample 3. The friction unit includes plastic sample 5, which is inserted into the housing of apparatus 6, mounted on thrust ballbearing 7. The temperature of the medium is regulated by heat exchanger 8 and is controlled by a thermometer. The device for measuring frictional force consists of a dynamometric beam with strain gauges 9, amplifier 10 and millivoltmeter 11.

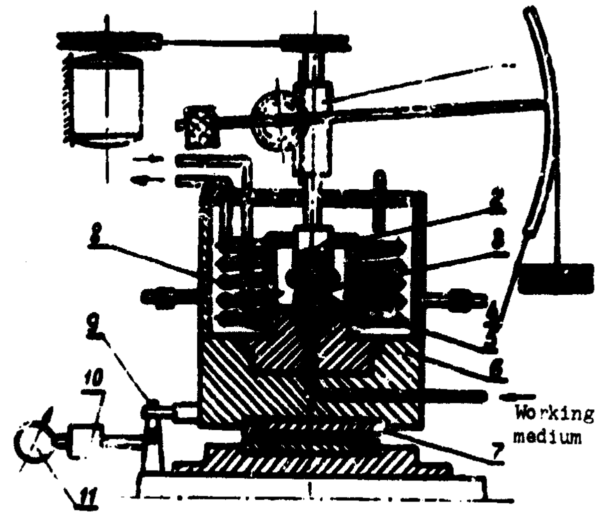

Fig. 1.

The adopted diagram of face contacting of hollow cylindrical samples with a coefficient of mutual overlap close to unity reflects the character of friction contact in the face packings of real pumps [1, 2].

The friction pairs were wet with water, which fed into the internal cavity of the samples and penetrated through the contacting surfaces outside into the housing.

The experiments were conducted according to the following method.

The samples were lapped on a cast iron plate, and the graphitoplast was lapped without the use of abrasive and lapping powders, and the plastic - with application of them [3]. The working surface was thoroughly washed with running water, then rubbed to mirror brightness with heavy paper. As a result of such treatment a high class finish was attained; the surface treatment - ∇10. Before testing the samples were degreased with gasoline.

Then all samples in the course of two hours were run-in on the friction machine at a specific working pressure of 0.56 kgf/cm^2. The investigations conducted by a number of authors showed that the

lapping of the graphite components assists in the creation of oriented films of graphite [4]. After preliminary running-in the samples are weighed on analytic scales with an accuracy of 0.0001 g and placed in the friction machine. The duration of the tests was equal to 8 hours with determination of wear by weighting after each two hours [4].

In testing each friction pair three experiments were conducted and for the result the arithmetic mean value of wear was taken. The deviation of the results was not more than 2-10% (Table 1). The relative average speed of slip equaled 7.1 m/s; the temperature of the water was 20°C.

Table 1.

Counterbody	Wear, mgf				
	2 h	2 h	2 h	2 h	Total
Plastic KF-10 (KVCh-9)*	2,0	0,8	0,8	0,8	4,4
Plastic KF-9	1,8	0,5	0,5	0,5	3,3
Graphitoplast ATM-1	1,2	0,2	0,2	0,2	1,8

*Material of laboratory No. 9, NIIPP.

From Table 1 it is clear that the maximum wear of graphitoplast is observed with the friction by plastic KF-10, into the composition of the filler of which, besides polytetrafluoroethylene [teflon-4], entered quartz sand. The highest wear resistance in water was manifested by the friction pair graphitoplast-plastic KF-9 into which as a filler there was teflon-4. The curve of the dependence of the friction coefficient on time is depicted in Fig. 2. (1 - for KF-9, 2 - for KF-10, 3 - for ATM-1).

The results of the experiments showed that in water there occurs an increase in the weight of the samples due to the swelling of the material. Therefore the swelling of graphitoplast was investigated depending upon the duration of its location in water. The magnitude of swelling was calculated by determining the magnitude of wear of the samples [5].

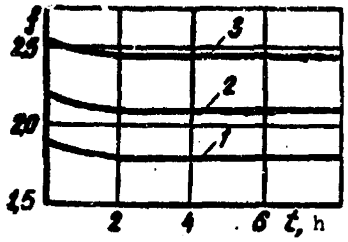

Fig. 2.

Tests were conducted at a temperature of 20°C. Material was submerged in water and kept there for a certain time (Fig. 3).

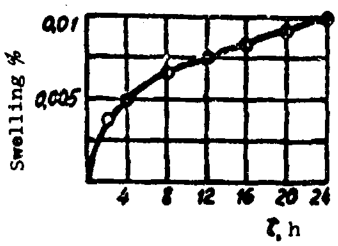

Fig. 3.

Conclusions

1. The magnitude of specific wear for the samples of graphitoplast within the limits of permissible operating conditions does not exceed 0.1 mgf/cm^2 h with friction by plastic KF-9 and 0.134 mgf/cm^2 h with friction by plastic KF-10.

2. The tests of silico-organic plastics with friction with graphitoplast showed that the best antifrictional properties are possessed by plastic KF-9.

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COMPARATIVE INVESTIGATIONS OF FRICTION OF REST OF CERTAIN PLASTICS WITH LARGE SPECIFIC LOADS

A. A. Kut'kov, D. T. Avdeyev, and
A. I. Romanovskiy

In contemporary designs of sluice gates guides are used consisting of a fixed rail and a mobile runner. The surface of the rail is faced with stainless steel and makes contacts with an insert of laminated wood plastic pressed into the runner. The complex conditions of operation of such a friction pair (water with the addition of abrasive particles, great specific pressures of up to 400 kgf/lin cm) in certain cases prevent the timely closing of the gate, which can lead to breakdown. Most frequently jamming of the lock occurs due to the increase in static friction during the time of fixed contact. Therefore the question of the selection of a friction pair able to operate under the above-indicated conditions with a minimum difference in the coefficients of static and sliding friction is extremely important.

We conducted experiments investigating the static friction of certain plastics paired with stainless steel under close to actual conditions. For this a special apparatus was designed, the diagram of which is depicted in Fig. 1. In order to avoid manufacturing a complex and bulky load system, it was decided to use a PSU-125 hydraulic press.

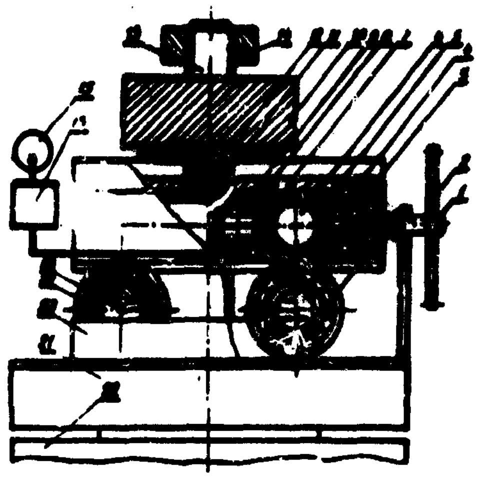

Fig. 1.

Fixed housing 20 of the apparatus is secured to self-adjusting table 21 of press 22. Slider 4 with the bath and with stainless steel plate 5 was moved on four ballbearings 19 planted at axis 18. The plate in cross section had a curvature with a radius of 200 mm, which corresponded to the profile of the rail used in the sluice gates. The slider was shifted by screw 1 with gate 2 and nut 3.

Sample 12 in the shape of a parallelepiped with dimensions 20 × 40 × 60 mm was secured stationarily in special holder 11 braced on crosspiece 10 of the press. Before beginning the experiment the crosspiece was lowered on screw stands 13 until contacting the sample with the plate. The necessary normal load was created and supported in the process of testing the press with hydraulic drive, with the help of which the table was raised upwards. The magnitude of load was checked by a manometer.

After compression of the samples the necessary time period elapsed. Then the shifting load was transmitted on the slider via the nut, sphere 6, thrust bearing 7 and tensometeric bushing 8. To the surface of a bushing were glued wire resistance transducers 9, which were joined into the circuit of the bridge and were connected to amplifier 16. The frictional force reading was carried out on low-inertia milliammeter, because the recording of frictional force on the film

of a loop oscillograph did not show a considerable increase in the accuracy of measurements. Before each experiment the bushing was calibrated with the help of a five-ton hydraulic press, but after the experiment the correctness of the calibration was checked and only in the case of its coincidence with the initial one was the result of the experiment considered correct.

For investigating friction in water into the bath there was poured technical water with a general rigidity of 16.3°H.

A total of four types of plastic were investigated: DSP-G wood plastic, textolite, P-68 resin and P-68 resin with powdery fillers. The surfaces of all samples were processed to a finish of ∇6, the surface of stainless steel – to ∇7. Before the experiment the friction surfaces were degreased with acetone. The maximum time lag of fixed contact corresponded to the conditions of the operation of sluice locks.

It is necessary to note that the static friction of antifriction bearings was not considered and all the results of the experiments were too high for this value. If one considers that the coefficient of static friction of antifriction bearings with a change in the normal load varies slightly, then it is possible on the average to accept an overestimated value of the coefficient of friction equal to 0.007.

The results of the experiments are given in Tables 1 and 2, where in Table 1 there are given the coefficients of dry friction, and in Table 2 – the coefficients of friction in water. Each result in the tables is the arithmetical mean of the results of three-four experiments.

Analyzing the results of the experiments, it is possible to draw the following conclusions:

1. The static friction for all samples decreases somewhat with an increase in normal load.

2. The coefficient of static friction for textolite increases most intensively with time.

3. Static friction in water for all samples is somewhat lower than dry static friction.

4. The lowest coefficients of friction belong to P-68 resin with powdery fillers. Besides this it has been visually established that pure P-68 resin has residual deformations due to insufficient mechanical strength.

Table 1.

Time of fixed contact, min	DSP-G wood plastic		Textolite		P-68 resin		P-68 resin with fillers	
	Normal load, kg/lin cm							
	1000	2000	1000	2000	1000	2000	1000	2000
	Coefficient of static friction							
0,5	0,41	0,38	0,22	0,20	0,25	0,23	0,15	0,13
5,0	0,40	0,34	0,29	0,27	0,28	0,26	0,16	0,13
10,0	0,40	0,32	0,38	0,37	0,29	0,27	0,16	0,14
30,0	0,39	0,31	0,57	0,55	0,30	0,28	0,17	0,15
60,0	0,37	0,31	0,62	0,60	0,32	0,30	0,18	0,16

Table 2.

Time of fixed contact, min	DSP-G wood plastic		Textolite		P-68 resin		P-68 resin with fillers	
	Normal load, kg/lin cm							
	1000	2000	1000	2000	1000	2000	1000	2000
	Coefficient of static friction							
0,5	0,40	0,38	0,30	0,28	0,20	0,18	0,12	0,10
5,0	0,39	0,34	0,32	0,30	0,22	0,20	0,12	0,11
10,0	0,38	0,32	0,39	0,35	0,23	0,21	0,13	0,11
30,0	0,37	0,30	0,51	0,46	0,24	0,22	0,14	0,12
60,0	0,35	0,30	0,56	0,50	0,27	0,23	0,15	0,13

Considering the low coefficient of friction of P-68 resin with powdery fillers and its insignificant increase with time, the sufficient mechanical strength of the plastic, it may be concluded, that this material is promising for use in guides of sluice hydrolocks.

DETERMINING PRESSURE IN A HIGH POLYMERIC MASS DURING ROLLING

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and A. I. Romanovskiy

In certain chemical manufactures the process of rolling is used to achieve final homogeneity of mass and the additional removal of solvent from it [1, 2].

Rolling is accompanied by great internal and external friction in the mass, and a large quantity of heat is liberated. Considering the direct dependence of the quantity of liberated heat on the operation of frictional force, it is necessary to recognize the important factor of pressure in the mass, since it is known that frictional forces are proportional to normal pressure. This factor to a definite degree can serve as a criterion of the stability of the technological process of rolling.

For determining pressure the method of indirect measurement has been used, i.e., the measurement of any parameter being functionally dependent on pressure.

The method of direct measurement of pressure in a rolled mass is unsuitable, since it is impossible to measure the direct influence of mass on the operating unit of an instrument. The measurement of pressure with the help of dynamometers and crushers does not make it

possible to record the rapid oscillations of pressure due to the great inertness of the rollers, therefore it also cannot be used in this case.

A method of determining pressure in a mass must satisfy the following requirements: 1) continuity of pressure measurement; 2) automatic recording of pressure parameters linked with time; 3) stability of the operation of the equipment for a period of 5 days.

To discover a parameter, which would be a function of pressure in a rolled mass, investigation of the operation of the rolling machine was carried out.

Let us consider an equation of the operation of a rolling machine: $A_л = A_c$, where $A_л$ – the operation of all effective forces, A_c – the operation of all resisting forces.

The operation of all resisting forces $A_c = A_{п.c} + A_т$, where $A_{п.c}$ – the operation of the forces of useful resistances, $A_т$ – the operation of friction forces.

In turn, the operation of the forces of useful resistances consists of the following components:

$$A_{п.с} = A_в + A_р + A_{о.т} + A_н.$$

where $A_в$ – the operation of pressing a cold particle into a heated mass, A_p – the operation of crushing a cold particle, $A_{o.т}$ – the operation of cutting tablets, $A_н$ – the operation of crumpling a hot mass, into which enters the work of shifting a mass along a roller.

Let us consider individually all the components, of which the operation of the forces of useful resistances consist. It is possible to assume that the properties of a hot mass approximate the properties of a liquid, and the properties of a cold mass – the properties of a

solid. Then with the forcing of a cold mass into a hot one, process will obey Newton's law for the movement of a solid in a liquid, i.e., $\delta = \frac{\lambda}{\eta}\tau$, where δ — the displacement rate of a solid particle in a liquid medium, λ — the parameter of the distribution of solid particles along the length of a roller, η — the viscosity of the liquid, τ — the pressure in the mass.

Since the fluted surface of the rollers does not allow relative slipping of cold particles, it may be concluded, that the depth of the pressing in will be a function of the angle of rotation of the roller:

$$\delta = f(\varphi), \tag{1}$$

where ϕ — the angle of rotation of the roller.

Having differentiated by equation time (1), we will find $\dot{\delta}$.

Then the pressure in the mass $\tau = \frac{\delta\eta}{\lambda} = \frac{f'(\phi)\cdot\eta}{\lambda}$ or in the general form $\tau = f_1'(\phi)$, since parameters η and λ can be considered constants.

The operation of pressing in will be equal to $\tau s\delta = f_1'(\phi)\cdot s\cdot f(\phi)$, where s — the total parameter of all pressed in particles, which with the uniform supply of the cold mass it is possible to consider constant.

Consequently, in the general form $A_B = f_2(\phi)\cdot s$.

Thus, the work expended on pressing the cold particles into the heated mass is a function of the angle of rotation of the rollers:

$$A_B = A_B(\varphi).$$

If a particle of cold mass according to dimensions is larger than the clearance established between the rollers, then after pressing it into a heated mass crushing of the particle will begin. Since a cold

mass with respect to its mechanical properties differs sharply from metals and does not obey Hooke's law with deformation, then it will be most correct to examine it as an elastic-viscous body.

A comparatively simple equation describing the process of the deformation of an elastic-viscous body is the Ishlinskiy equation:

$$\dot{T} + r_1 T = \dot{\delta}_1 b + Bn\delta_1, \tag{2}$$

where $\dot{T}$ – the rate of application of the load; T – the force acting on the particle; $\dot{\delta}_1$ – the rate of deformation; δ_1 – the magnitude of deformation r_1, n and b – the rate of relaxation, the rate of aftereffect and the rigidity of the deformed body [3].

It is obvious that the magnitude of deformation and its rate will be functions of the angle of rotation of the roller. Then differential equation (2) will have the general form: $T = f_3(\phi)$, since r_1, n and b are constants.

Multiplying T by λ and δ_1 we obtain the work expended on crushing $A_p = T\lambda\delta_1 = \lambda \cdot f_3(\phi) \cdot f(\phi)$, i.e., the work of crushing is a function of an angle of rotation:

$$A_p = A_p(\varphi).$$

The work of cutting tablets can be disregarded, since it is small. The work expended on crumpling a hot mass can be expressed through the work of circumferential force P on a certain shift, where $P = \frac{kN}{r}$, where k – the proportionality factor or the coefficient of rolling friction, N – the magnitude of a normal load on a hot mass, r – the radius of the roller.

Since a shift along the circumference will also be a function of an angle of rotation, then

$$A_\kappa = A_\kappa(\varphi).$$

Thus it has been established that the work of all the forces of useful resistances is a function of the angle of rotation of the roller

$$A_{п\text{-}с} = A_{п\text{-}с}(\varphi).$$

The work of the friction forces in the bearings of the shafts will be expressed as a moment of frictional force multiplied by an angle of rotation $A_T = M_T \phi$.

It is known that friction moment $M_T = Rf\frac{d}{2}$, where R – the total reaction at the supports, f – the coefficient of sliding friction in the supports, d – diameter of the journal.

It is obvious that with a constant pressure between the rollers the work of the friction forces will be a function of the angle of rotation:

$$A_т = A_т(\varphi),$$

Thus, the equation of machine work is

$$A_д = A_{пс}(\varphi) + A_т(\varphi),$$

The work of the effective forces is equal to the product of the torque by the angle of rotation, Consequently,

$$M_к = \frac{A_{пс}(\varphi) + A_т(\varphi)}{\varphi}, \tag{3}$$

where $M_к$ – torque.

Torque will remain constant with the preservation of the constants of all parameters of the rolled mass.

Let us write equation (3) in the expanded form:

$$M_{\text{к}} = \frac{\tau s\delta_1 + T\lambda\delta_1 + kN\varphi + Rf\frac{d}{2}\varphi}{\varphi},$$

$$M_{\text{к}} = \frac{\tau s\delta}{\varphi} + \frac{T\lambda\delta_1}{\varphi} + kN + R\cdot f\cdot \frac{d}{2}.$$

All members of the right side of the last equation contain the magnitude τ, T, N, and R depending on the pressure in the mass. Therefore torque with a constant number of turns (which is observed in rolling) is a function of the pressure in the mass located between the rollers

$$M_{\text{к}} = M_{\text{к}}(T_{\text{сум}}),$$

where $T_{\text{сум}}$ – the total pressure.

Considering the functional dependence of torque on pressure in a mass located between the rollers it is possible to conclude, that indirect measurement of pressure in a rolled mass is possible by measuring the torque on the driving shaft with corresponding calibration of the instrument.

The most convenient, exact and contemporary method of measuring torque is by the use of wire resistance transducers glued on the shaft. The developing impulse with the help of a special slip-ring is supplied to a potentiometer and can be recorded on paper tape. This method of measuring torque on the shaft of a screw press which has shown high accuracy and stability of operation has been developed and tested in our laboratory. The employed equipment is general-purpose and without alterations can be used for measuring torque on the driving shaft of rollers.

Since the majority of parameters determining the mechanical properties of a mass (rheological constants, viscosity, coefficients of internal and external friction and others) are unknown, then to determine by calculation the dependence of torque on pressure in a mass is impossible. Therefore direct calibration with respect to a

previously known pressure is necessary. The calibration can be carried out with help of dynamometers or crushers built-into the rollers. However this is connected with great design and technological difficulties.

We proposed a simpler and sufficiently exact method of calibrating by passing between the rollers of bands of soft metal, for example copper.

It is known that the rolling moment of a copper band is expressed by the following formula [4]: $M_{пр} = 2P_{cp}\psi b_{cp} r\Delta h$, where P_{cp} – the average specific pressure on the rollers, b_{cp} – the average width of the band before and after rolling, Δh – the difference in the thickness of the band before and after rolling, ψ – the coefficient of an arm of resultant pressure of a metal on rollers (it is assumed equal to 0.48 [4]), r – the radius of the roller.

From this equation we determine the average pressure:

$$p_{cp} = \frac{M_{пр}}{2\psi \cdot b_{cp} \cdot r \cdot \Delta h}.$$

It is possible also to use the prepared data on the rolling of copper bands, available in literature. For example, according to Korolev [5], in the rolling of a copper band with a width of 50 mm with a thickness of from 3.0 to 1.8 mm on rollers with a diameter of 250 mm there was obtained an average pressure of 45 kgf/mm^2. According to the same author, in a narrow range of tape width the magnitude of total pressure is proportional to the width of the band. Consequently, by changing the width of the band, it is possible to calibrate the instrument at a different pressure range.

Conclusions

1. Direct methods of measuring pressure are unsuitable for measuring pressure in a rolled mass.

2. The use of dynamometers crushers is possible, however it is connected with great difficulties and does not ensure continuous measurement of pressure.

3. Torque on a driving shaft depends on the pressure in the mass.

4. For measuring pressure in a rolled mass there has been proposed the use of an indirect method consisting of measuring torque.

5. **There** has been recommended for this purpose the use of general-purpose equipment created by the laboratory for measuring torque on the shaft of a press.

6. There has been developed a method of direct calibration of an instrument by rolling copper bands with different width.

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ANTIFRICTION PROPERTIES AND WEAR RESISTANCE OF POLYAMIDE RESINS WITH A GRAPHITE FILLER IN LUBRICATION WITH WATER

M. Sh. Imanov

For the creation of simple and reliable designs of immersed electric pumps of especially great importance is the broad introduction of friction pairs operating well on water lubrication and not requiring the use of scarce materials. The metal-rubber friction pairs utilized at present under unstable operating conditions, when the lubricating water wedge is absent, quickly wear out.

In NPI the laboratory of new antifrictional materials there has been produced a plastic material based on polyamide resins with a graphite filler. The purpose of this work is the investigation of the antifriction properties and the wear resistance of this material paired with stainless steel lubricated by water, as applied to the operating conditions of friction units of immersible electric pumps.

A study of the antifrictional properties and the wear resistance of polyamide resins with a graphite filler in combination with stainless steel was carried out both with hydrodynamic, and also with imperfect lubrication.

As a lubricant tap water with a general hardness of 16.23°H at a temperature of 10-20°C was used. The plastic samples were made in the form of cylindrical bushings with a length of 17.846 mm, and the surface of the samples tested with hydrodynamic lubrication was treated along the profile ensuring these operating conditions.

The metallic samples are made of stainless steel not-heated to redness. Their surface was lapped on a plate with lapping powders to a finish of $\nabla 9$. After this the sample was thoroughly washed to remove the abrasive. The finish of the surface of the plastic sample corresponded to $\nabla 6$. In testing the following external parameters were adopted:

a) with hydrodynamic lubrication: the number of turns n = 3250 r/min, slip rate v = 7 m/s, specific pressure q = 10 and 15 kgf/cm^2, area of the friction surface S = 2.1 cm^2;

b) with imperfect lubrication: v = 7 m/s, q = 8 kgf/cm^2, S = 3.4 cm^2.

The linear method of measuring wear and swelling (with a micrometer) was adopted. The amount wear was determined according to the following formula:

$$U = l_{\text{исх}} + \Delta l - l_{\text{р}},$$

where $l_{\text{исх}}$ – the length of the plastic sample before wear; Δl – the swelling of the sample, corresponding to the time of wear measurement: $l_{\text{р}}$ – the length of the sample after wear.

The antifriction properties of the tested pair of materials were determined by the value of the friction coefficient. The friction moment arising during the friction of the samples was determined by tensometering. On beam 7 (Fig. 1) wire resistance gages were glued. Under the effect of the friction moment cup 3 tending to turn was pressed on the end of the beam by lever 6. With deflection of the

beam the electrical resistance of the wire changed, and with respect to this change it was possible to judge the amount of deformation of beam. The electrical signal was fed through the amplifier to the instrument, which showed the magnitude of the moment of friction (after calibration).

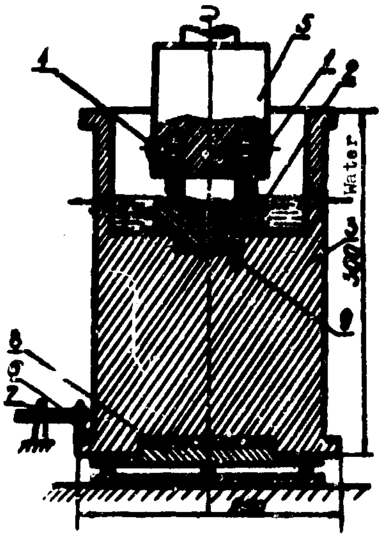

Fig. 1.

Knowing the moment of friction $M_{тр}$ and load N it is possible to determine the coefficient of friction:

$$f = \frac{3.1M_{тр}(r_2^2 - r_1^2)}{2N(r_2^3 - r_1^3)}. \tag{1}$$

where r_1 and r_2 – the internal and external radii of the plastic sample. Each test was repeated three times.

In Fig. 1 the working unit of the face friction machine is shown. Into spindle 5 of the machine plastic annular sample 1 was inserted, being rubbed by the face-surface on fixed sample 2. The rotation of sample 1 inside the spindle was prevented by two set screws 4. Sample 2 placed in a cup with water; its rotation was prevented by screw 9. During the operation of the machine sample 1 tended to

start into rotation sample 2, and consequently, water cup 3. The rotation of the cup was prevented by the rest, which was simultaneously tensometeric beam 7. The designed apparatus makes it possible to carry out testing at 400, 1400, and 3250 r/min.

At the beginning of the tests the swelling of the plastic sample was determined. In Fig. 2 a curve is constructed, showing the change in swelling depending upon time. After 48 hours the average magnitude of swelling was 0.021 mm, subsequent swelling did not occur.

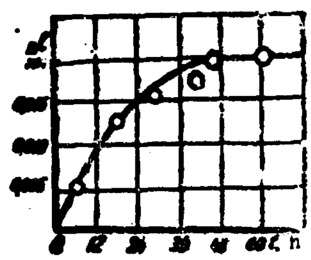

Fig. 2.

After this the values of wear and the coefficient of friction with hydrodynamic lubrication were determined. Under such operating conditions wear of the plastic sample was observed only during starts and stops (after 2-3 hours of operation). The value of wear of the plastic sample (at pressures of 10 and 15 kgf/cm^2) is given in Table 1.

After 50 hours of operation wear on the surface of the steel sample could not be detected. The working surfaces of the steel and plastic after the experiments were mirror-like. On the average the coefficient of friction for the pair was 0.007-0.008.

Subsequently tests were conducted with imperfect lubrication, since the antifriction properties and the wear resistance of the materials more clearly appear during operation under such conditions.

The shape, the surface finish and the dimensions of the samples were the same, but the surface of the plastic samples was made without a profile, providing a hydrodynamic regime of friction. The amounts of wear are given in Table 1. After 31 hours of operation wear on the steel sample could not be detected. The surfaces of both samples were mirror-like. The coefficient of friction was determined by formula (1) at a different time.

Table 1.

Lubrication	Specific pressure, kgf/cm²	Operating time, h	Wear, mm
hydrodynamic	10	3	not observed
		15	0,016
		21	0,020
		28	0,025
		40	0,035
		47	0,040
		50	0,045
	15	1	not observed
		8	0,015
		13	0,020
		20	0,025
		26	0,030
		30	0,034
		35	0,038
imperfect	8	3	0,012
		10	0,037
		17	0,059
		24	0,075
		31	0,090
		38	0,120
		45	0,126

Then the dependence of the coefficient of friction on specific pressure (Fig. 3) was investigated at different times after the beginning of operation (curve 1 - after 1 min, curve 2 - after 5 h, curve 3 - after 24 h). From the chart it is clear that with the increase of specific pressure to 13-14 kgf/cm² the coefficient of friction decreases, and then remains constant.

Fig. 3.

Conclusions

1. The swelling of the tested plastic sample was insignificant.

2. The most intense wear of a plastic sample is observed during the running-in period.

3. The amount of wear of a plastic sample in lubrication with tap water is insignificant.

4. The wear of steel samples is practically absent.

5. Coefficient of friction of this pair in hydrodynamic lubrication with water is 0.007-0.008, and in imperfect lubrication 0.09-0.02 (the larger value corresponds to the beginning of operation).

6. The coefficient of friction decreases to a certain limit with an increase in specific pressure.

COMPARATIVE INVESTIGATION OF THE FRICTION OF STEEL AND PLASTIC SAMPLES UNDER THE EFFECT OF SHOCK LOADS

D. T. Avdeyev and S. N. Litvinenko

In contemporary machines there are friction subassemblies operating under sharply changing shear loads, close to shock loads. The friction with such loads has almost not been studied, and a method of testing does not exist. Therefore investigations of this type are of great interest.

We investigated the sliding friction of steel and plastic samples paired with steel during shock load. An experimental device was assembled from a pendular hammer and special attachment to it.

The attachment (Fig. 1) had stand 1 with two levers 2. With the suspension of loads 3 the levers transmitted force to movable pins 4, between which was pressed sample 5 located in mandrel 6. The use in the attachment of two levers made it possible to place the sample exactly in the center. Before placing the sample the pendulum of the pile driver was raised to the upper position. The sample was held in the fixed state for a definite time, then the pendulum was released, which, striking the hardened mandrel, drove it from the attachment. From the height of the rise of the pendulum after the blow there was determined the work expended in overcoming the friction of the surfaces of the sample on the surface of the pins.

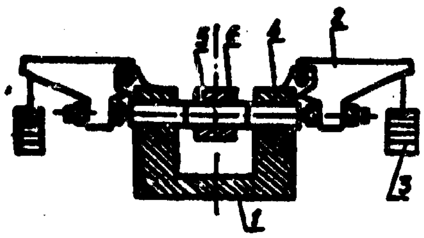

Fig. 1.

In order to eliminate the work expended on increasing the kinetic energy of the sample with the mandrel, they before the experiment were suspended in the zone of the impact on thin wires. After this an impact was produced and the work was determined, which had been expended on imparting the kinetic energy to sample with mandrel without friction.

The experimental data were processed by the formula:

$$f = \frac{A - A_{\kappa}}{sN},$$

where f – the coefficient of sliding friction, A – the complete work in knocking out the sample, A_{κ} – the work expended on increasing the kinetic energy of the sample, s – the path of friction, N – the normal load on the sample.

With respect to the above described method at first the effect of increasing the normal load on the coefficient of friction with impact was investigated for a steel-steel pair with dry and with boundary lubrication.

The length of a steel sample of steel 3 equaled 20 mm, a diameter of 10 mm. Its faces being friction surfaces were treated to a class 6 finish. The same processing finish was also possessed by the friction surfaces of the pins made of steel 45. With dry friction the surfaces were degreased with carbon tetrachloride; in the investigating boundary friction – they were lubricated with a fine layer of ricinoleic acid. The holding of the samples in the fixed position lasted one minute.

The results of the experiments are shown on the graph (Fig. 2), where each point of the curves is the average value of the results of six experiments. It is readily evident that the coefficient of friction increases with an increase in load considerably faster with friction dry (curve 1) then with boundary friction (curve 2).

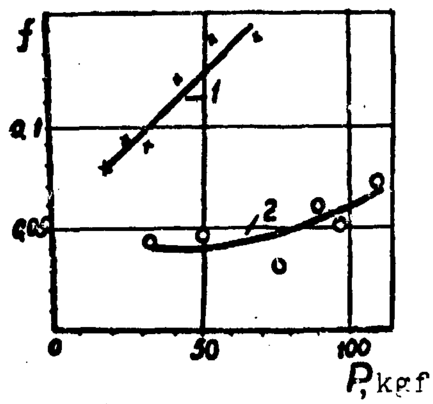

Fig. 2.

Thus, it is possible to draw the conclusion that for a steel-steel pair with identical loads the Amontons-Coulomb law is correct only for boundary friction conditions.

Then the friction of plastic samples on steel was investigated. Samples of the same dimensions as the others were made from polyethylene with fillers. The surface processing corresponded to class 6 finish.

The experimental method was analogous to that used for the steel samples. The experiments were conducted with dry friction (the steel surfaces were degreased, and the plastic ones were thoroughly lapped) and with lubricant TsIATIM-201, which, as is known, forms good boundary layers on the surface of plastics.

The results of experiments showed (Fig. 3) that with dry friction (curve 1), a greater spread of points is observed than

with boundary friction (curve 2). With an increase in load the coefficient of friction decreased with dry friction, and with boundary friction was changed insignificantly.

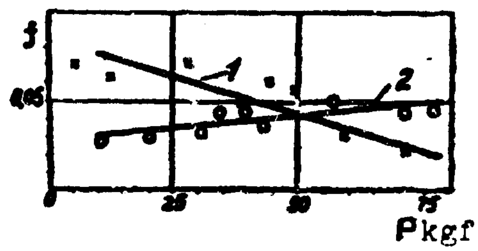

Fig. 3.

Consequently, it is possible to draw the conclusion that the Amontons-Coulomb law is corrected only for the boundary friction of steel-steel and steel-plastic frictional pairs under the effect of shock loads.

INVESTIGATING THE EFFECT OF CERTAIN TYPES OF CORROSION INHIBITORS AND ANTICORROSIVE COVERINGS ON THE WEAR-RESISTANCE OF A STEEL-POLYAMIDE FRICTION PAIR WITH OPERATION IN WATER

A. A. Kut'kov and V. I. Vishnyakov

The existing antifrictional materials (bronze, babbitt) in most cases are absolutely unsuitable for work in water due to the increased wear of the high coefficients of friction and the susceptibility to corrosion.

At present numerous works are being conducted on selecting or developing antifrictional materials intended for operation in water. Especially promising materials are the high polymers or the plastics based on them. In many cases the polyamide resins of the caprone type, P-68 and others have acquitted themselves well.

Numerous investigations have shown that one of the significant deficiencies of polyamide resins as antifrictional materials is the considerable wear of the journals of steel shafts. For a long time this phenomenon did not receive an explanation, but the works of G. V. Vinogradov [1], and also those of V. A. Kargin and G. L. Slonimskiy [2] revealed the essence of the processes occurring on the friction surface of polyamides. The surfaces of plastics, especially polyamides, in the presence of friction are distinguished

by their high chemical activity, which is explained by the process of the breaking of the macromolecules with subsequent formations of free radicals and ion-radicals. The radicals formed under the effect of oxygen in the air are rapidly changed into peroxides, which are active oxidizers, which bring about oxidizing wear of a steel surface.

According to the classification of B. I. Kostetskiy [3] oxidizing wear is that type of wear, in which the characteristics of the work of friction depend on the phenomena of oxygen diffusion into the surface layer of a metal deformed by friction and the formation of a solid solution of oxygen in the metal and its chemical compounds (for iron: FeO, Fe_3O_4, Fe_2O_3). Thus, it is possible to expect that with friction of steel on a polyamide in water there will be observed intense oxidizing wear of the steel. In the presence in water of corrosion inhibitors or in the presence on a steel surface of a layer of anticorrosive covering the wear of steel can be decreased.

For checking the effect of corrosion inhibitors and anti-corrosive coverings on the wear resistance of steel with friction in water experimental investigations were carried out. Experiments were conducted on a face friction machine (Fig. 1). The upper rotating sample 4 in the form of a bushing ($Dxd = 24 \times 18$ mm) was made of steel (steel 45) with a finish of a working surface of $\nabla 9$. Lower sample 5 having the shape of a disk was made of P-68 resin. Its working surface was machined on a lathe to a finish of $\nabla 7$. The moment of friction was measured with electric strain gages 1 glued onto bracket beam 2. The magnitude of the moment of friction (the coefficient of friction) was recorded on the tape of a potentiometer. Specific load in all cases equaled 10 kgf/cm^2, and the peripheral velocity — 1.2 m/s. Of the corrosion inhibitors of steel there were selected calcium bicarbonate ($Ca(HCO_3)_2$), sodium nitrate ($NaNO_3$), sodium sulfate (Na_2SO_3) and gallic acid ($C_7H_6O_5$). Calcium bicarbonate forms on the surface of steel films of insoluble carbonates; sodium nitrate possesses a passive action, sodium sulfate absorbs oxygen, and gallic acid provides shielding of the surface [4].

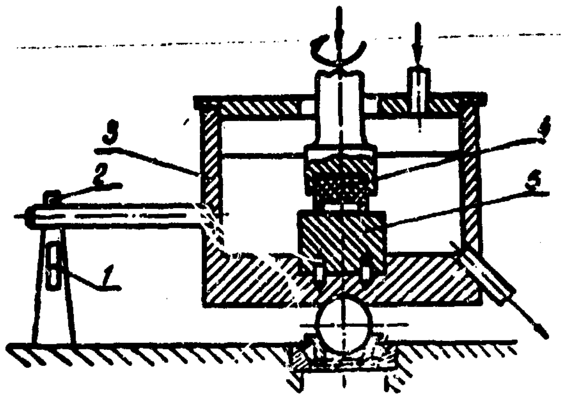

Fig. 1.

In all cases of the tests were conducted in a 2% solution of inhibitor in tap water, which was poured before each experiment into bath 3 (Fig. 1). Of the protective coverings there were selected alkaline and acid oxidizing, parkerizing and burnishing. In tests with inhibitors each experiment lasted 15 hours. The time was established by a series of preliminary experiments, which showed that during 15 hours of operation under the above-indicated regimes of friction, a steel sample wore in water by 30 μm. This value, according to our assumptions, constitutes a sufficient criterion for comparison with the values of other wears. In investigating the effect on wear resistance of anticorrosive coverings an experiment was terminated as soon as the covering was worn off, which was indicated by the variation in the value of the coefficient of friction. In Fig. 2 a graph is depicted, showing the amount of wear of a steel sample during operation in water without inhibitors 1 and with inhibitors: calcium bicarbonate 2, sodium nitrate 3, sodium sulfate 4 and gallic acid 5. In Fig. 3 shown curves are characterizing the value of the coefficient of friction during operation in the same media. In Fig. 4 a graph is depicted, showing the value of wear during operation in water of a steel sample without coverings 1 and steel samples with coverings produced by alkaline oxidizing 2, acidic oxidizing 3, parkerizing 4 and burnishing 5, and in Fig. 5 – curves characterizing the value of coefficients of friction.

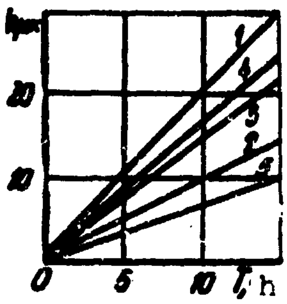

Fig. 2.

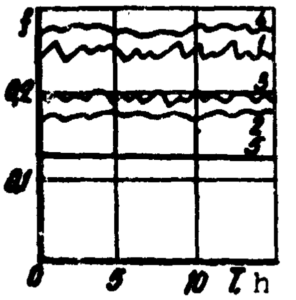

Fig. 3.

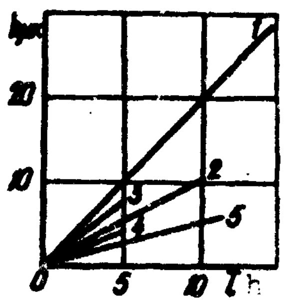

Fig. 4.

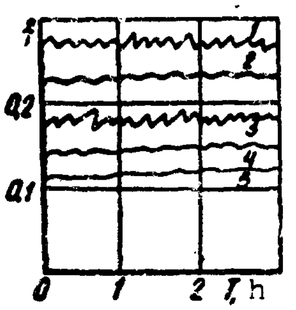

Fig. 5.

The investigations show that the corrosion inhibitors and the anticorrosive coverings have a definite effect on the antifriction characteristics and the wear resistance of steel under the effect of friction. Thus, the wear of a steel sample during the time of testing with operation in water containing 2% gallic acid was three times less than the wear of the same sample operating in water. The wear of steel is considerably decreased by calcium bicarbonate forming films of insoluble carbonates on a friction surface.

The coefficients of friction also to a considerable extent depend on the presence of corrosion inhibitors and anticorrosive coverings. For example the coefficient of friction with the presence of gallic acid in water is reduced by half. Furthermore, the character of friction is noticeably changed; it becomes more even, smoother. The use of calcium bicarbonate also decreases friction.

Coverings also decrease oxidizing wear and in certain cases considerably reduce the coefficients of friction. Coatings produced by burnishing and then by alkaline oxidizing work better in water than others.

Conclusions

1. Corrosion inhibitors have a significant effect on the wear resistance and the frictional properties of steel under conditions of oxidizing wear. With the presence in water of certain inhibitors oxidizing wear of steel is decreased and the value of coefficients of friction is reduced.

2. Certain antifriction coverings to a considerable extent decrease the oxidizing wear of steel and improve the frictional characteristics.

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CERTAIN QUESTIONS CONCERNING THE FRICTION OF PLASTICS BASED ON POLYAMIDE RESINS WITH A FILLER WITH WATER LUBRICATION

A. A. Kut'kov and M. Sh. Imanov

In work [1] there was expounded a method and certain results of investigations of the antifriction properties and the wear resistance of plastics based on polyamide resins with a filler when operating paired with stainless steel and with tap water lubrication.

In the present work new results are given obtained in the investigation of the antifriction properties of the above-mentioned material when operating paired with stainless steel and bronze. Tests were also conducted in tap water. Furthermore, there are given empirical formulas obtained in the mathematical processing of experimental data, which can be used in engineering calculations.

The running-in time of plastic samples was determined by plotting a graph of the dependence of the coefficient of friction on operating time (Fig. 1), inasmuch as the methods of Gersi and M. M. Khrushchov [2] for this group of materials are unsuitable. During testing the temperature of the surface and the slip rate remaining constant, for which the coefficient of friction did not change after running in. In Fig. 1 transition point A is noted, the abscissa of which shows the running-in time of the material. This is also confirmed by the state of the friction surface, since at the time corresponding to

the time of termination of running in the surface acquires a mirror-like luster [3]. The experiments show that the time of running in of the tested plastic in operation in tap water on stainless steel is 5 hours, if p = 3.5 kgf/cm^2 (curve 1) and 4 hours, if p = 6 kgf/cm^2 (curve 2).

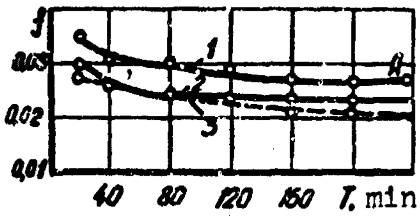

Fig. 1.

Tests were subsequently carried out to evaluate the antifriction properties of polyamide with a filler when operating paired with bronze. The bronze sample had a surface finish of ∇8, the polyamide sample – ∇5. The dependence of the coefficient of friction on the duration of testing is shown in Fig. 1 (curve 3). The tests were conducted under a specific pressure of 6 kgf/cm^2. After 36 hours of operation the wear of the polyamide sample was 0.03 mm, and of the bronze one – 0.015 mm. The linear wear was measured with a vertical optimeter. Then the specific pressure was increased to 10 kgf/cm^2. After 25 hours the wear of the polyamide and bronze samples was respectively with 0.02 and 0.015 mm. The coefficient of friction did not exceed 0.03. In Fig. 2 there is depicted the dependence of the coefficient of friction on specific pressure for this same friction pair.

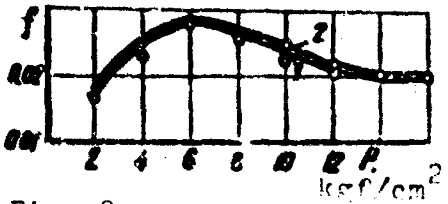

Fig. 2.

The mathematical processing of the experimental data to develop the functional dependences of the coefficient of friction on specific pressure, and also of swelling on time, were carried out by the methods of "least squares" and "mean squares."

For a polyamide with a filler-stainless steel friction pair the formula has the following form:

$$f = \frac{k}{p^{\alpha}} + f_{nc}, \tag{1}$$

where k and α – coefficients dependent on the material, f_{nc} – a constant of the coefficient of friction (asymptote along the f axis).

$$f_{nc} = \frac{f_1 f_2 - f_s^2}{f_1 + f_2 - 2f_s}. \tag{2}$$

To determine f_{nc} we take on the graph (Fig. 3) three points with abscissas p_1, p_2, and $p_s = \sqrt{p_1 p_2}$ and ordinates f_1, f_2, and f_s respectively (p_1 and p_2 are selected arbitrarily). Then $f_{nc} = 0.02$.

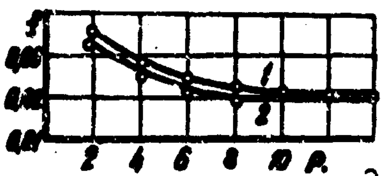

Fig. 3. kgf/cm^2

To determine the coefficients k and α we use the method of "least squares." Let us designate the sum of deviation for all experiments through S.

After logarithmization of formula (1) we obtain

$$S = \sum_{i=1}^{n} [\lg(f_i - f_{nc}) - \lg k + \alpha \lg p_i]^2.$$

Differentiating this equation with respect to k and α, we obtain

$$\begin{cases} \dfrac{\partial S}{\partial k} = 2\sum_{i=1}^{n}[\lg(f_i - f_{nc}) - \lg k + \alpha \lg p_i]\left(-\dfrac{0{,}434}{k}\right), \\ \dfrac{\partial S}{\partial \alpha} = 2\sum_{i=1}^{n}[\lg(f_i - f_{nc}) - \lg k + \alpha \lg p_i]\lg p_i, \end{cases} \tag{3}$$

where n – the assigned number of specific pressure ($n = 6$). Thus, in order to determine k and α, we solve the equations (3), using the following conditions:

$$\frac{\partial S}{\partial k} = 0; \quad \frac{\partial S}{\partial \alpha} = 0.$$

For the tested pairs $k = 32 \cdot 10^{-3}$, $\alpha = 1.2$. In Fig. 3 there was shown experimental curve 1 and theoretical curve 2 obtained by formula (1).

The analytical expression for a polyamide-bronze friction pair has the form:

$$f = \frac{p}{p(kp - \delta) + c} + f_{nc}. \tag{4}$$

where δ and c – the coefficients dependent on the material. Value $f_{nc} = 0.015$ we determine by formula (2). To determine k and δ we use the method of "mean squares." We introduce a new variable $f' = \frac{p}{f - f_{nc}}$ and we obtain

$$f' = kp^2 + \delta p + c.$$

Since value p forms an arithmetical progression with a difference $h = 2$, then is adjusted $f'' = \Delta \frac{p}{f - f_{nc}}$, where f'' – the difference of each of the following two values of f'. After which the following dependence is obtained:

$$f'' = (\delta h + kh^2) + 2khp$$

Making up the deviation $\varepsilon_1 = f_1 - (\delta h + kh^2) - 2khp_1$, where $i = 2, 4, \ldots, 12$, and dividing it into two groups, we obtain

$$\begin{gathered}\varepsilon_1+\varepsilon_2+\varepsilon_3=0\\ \varepsilon_4+\varepsilon_5+\varepsilon_6=0.\end{gathered} \tag{3}$$

After solving the equations (5) $k = 0.033 \cdot 10^3$ and $\delta = 0.37 \cdot 10^3$.

Coefficient c is determined from equation

$$\sum_{i=1}^{n} f_i' = k\sum_{i=1}^{n} p_i^2 + \delta\sum_{i=1} p_i + nc.$$

After intermediate calculations $c = 1.56 \cdot 10^3$. In Fig. 2 there are shown experimental curve 1 and theoretical curve – 2, obtained by formula (4).

Subsequently there was determined the dependence of the swelling of the tested polyamide on time (Fig. 4). The formula characterizing this dependence has the following form:

$$\Delta l = \Delta l_0 (1 - e^{-\frac{t}{a_1}}), \tag{6}$$

where Δl – the linear swelling, mm; Δl_0 – the constant of linear swelling (determined analogous to formula (2), mm; t – the time of the location of the sample in the water, h: a_1 – a coefficient dependent on the temperature of the water and on the material.

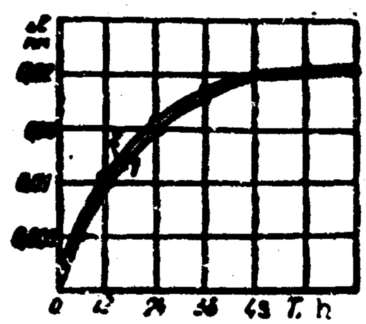

Fig. 4.

Coefficient α_1 is determined by the method of "least squares":

$$S = \sum_{i=1}^{n}\left(\ln \frac{\Delta l_0 - \Delta l_i}{\Delta l_0} + \frac{t_i}{\alpha_1}\right)^2.$$

Having differentiated this formula, we will obtain

$$\frac{dS}{d\alpha} = 2\sum_{i=1}^{n}\left(\ln \frac{\Delta l_0 - \Delta l_i}{\Delta l_0} + \frac{t_i}{\alpha}\right)\frac{t_i}{\alpha}. \quad (7)$$

Thus, with condition $\frac{dS}{d\alpha} = 0$, by formula (7) we determine $\alpha_1 = 0.017 \cdot 10^3$.

In Fig. 4 empirical curve 1 and theoretical curve 2 are shown, obtained by formula (6).

Conclusions

1. The antifriction properties of polyamide resins with a filler with friction on steel and bronze with tap water lubrication are satisfactory.

2. The running-in time of plastics based on polyamide resins with a filler has been determined.

3. The empirical dependences of the coefficient of friction on specific pressure and swelling on time, which can be used for engineering calculations have been obtained.

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THE INVESTIGATION OF THE WEAR RESISTANCE OF CERTAIN POLYMERS DURING OPERATION IN WATER

A. A. Kut'kov and Yu. B. Kornilov

Because of the broad application in industry and in the national economy of plastic components there is great interest in the question of the wear resistance of these materials.

At present a single universal wear classification does not exist of components of machines and mechanisms, made both from metal, and also from plastics. A number of authors in our time have proposed different wear classifications. Thus, there are known the classifications of A. K. Zaytsev, G. M. Zamoruyev, B. I. Kostelskiy, I. V. Kragel'skiy, M. M. Khrushchov and others. The majority of authors distinguish abrasive wear as an independent catagory. It is necessary to note that abrasive wear is one of the widespread types of wear, therefore the investigation of abrasive wear of plastics is of definite interest.

The method of investigating abrasive wear under laboratory conditions developed by M. M. Khrushchov exists, and special equipment for carrying out this type of investigation has been created [1], [2]. Furthermore, S. B. Ratner has proposed a method of investigating wear of plastics on a screen [3], [4], [5].

Since we were confronted with the problem of carrying out the laboratory investigation of the wear of plastics with friction in water, the indicated methods could not be used. On the basis of the works of M. M. Khrushchov and S. B. Ratner a method of wearing plastics with perferential abrasive wear in a friction process in the presence of water was developed. For carrying out experiments a testing device was designed in the faculty department, the prototype of which was the machine of M. M. Khrushchov, the Kh4-B. As an abrading surface a metal screen was adopted. The testing device is shown in Fig. 1. Metal screen 2 is fastened to disk 17 revolving horizontally, having special collars 1 for holding the water on the surface of the screen. The disk is driven by electric motor 12 via transmission 13, having five speeds, V-belt transmission 14 and conical pair 16. Sample 10 is placed in special clamp holder 4, to which load 5 is braced, pressing the sample to the screen. The clamp holder together with the sample and the load is placed in bushing 6, along the axis of which it freely moves on special guides preventing the turning of the holder. The bushing via plate 3 is fastened to head 7, which by rod 8 with a thread and spline and nut 9 can move along the radius of the disk. Frictional force is measured by wire resistance transducers glued to the plate. Revolution counter 11 is connected to horizontal shaft 15.

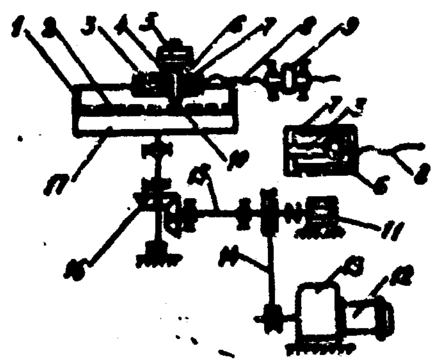

Fig. 1.

The investigation of the wear of polymers was conducted on samples with a diameter of 4 mm. Organic glass served as a standard. A maximum specific pressure was selected experimentally; it equalled 4.2 kgf/cm^2, which excluded the spreading of the polymer in the contact zone. The investigations were carried out according to the following method. A sample of the test material with a length of 28-30 mm was thoroughly processed on its cylindrical surface. In a special attachment the ends of the sample were lapped with an abrasive cloth of fine mesh in such a way, that the ends were parallel.

Before the beginning of the experiment the sample was measured with a micrometer to an accuracy of 0.002 mm; then the sample was secured in the clamp holder, together with which it was placed in the bushing. The load on the clamp holder created a specific pressure of the sample on screen, equal to 4.2 kgf/cm^2. The wear of the sample was determined after a 100 m path of dry friction of the sample on the screen and with the presence of a layer of tap water on the screen. The speed of slip of the sample on the screen was 4 m/min.

The tested materials were several types of high polymers with a different percentage of filler. As the initial polymers polyamides were used; graphite served as the filler. The obtained materials were arbitrarily designated Nos. 1, 2, 3, 4, and 5. Standard samples of organic glass were tested in parallel under identical conditions to compare the wear of the tested material with the wear of the standard material. The products of wear were removed from the friction surface with the help of a special brush.

In the process of conducting the experiments it was established that the test samples had under specific friction conditions uniform wear, proportional to the friction path.

As a result of the conducted investigations dependences were obtained of the absolute wear of the investigated samples Δl on friction path S with a specific friction regime (V = 4 m/min, q = 4.2 kgf/cm^2) for friction on a dry screen and for friction on a screen covered with a layer of tap water.

Analyzing the obtained results, it was possible to note that wear with friction on a dry screen (Fig. 2) was considerably higher than wear with friction on a screen moistened with water (Fig. 3). Thus, for material No. 1 - by 2.53 times, No. 2 - by 3.32 times, No. 3 - by 2.24 times, No. 4 - by 4.55 times, No. 5 - by 2.82 times. The increased wear of the investigated materials with friction on a dry screen, as compared to wear with friction on a screen covered with water, apparently, must be explained by the effect of increased temperature appearing with the friction in the first case and by its absence in the second - in connection with the constant cooling with water of the surfaces of the friction bodies.

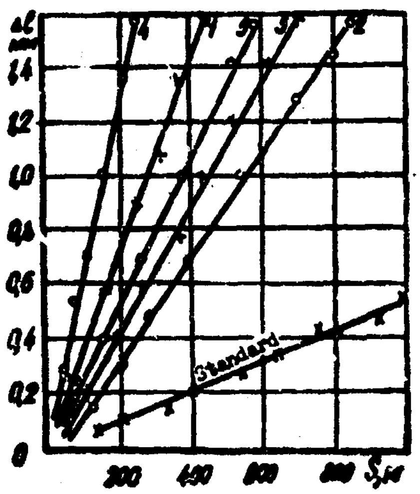

Fig. 2.

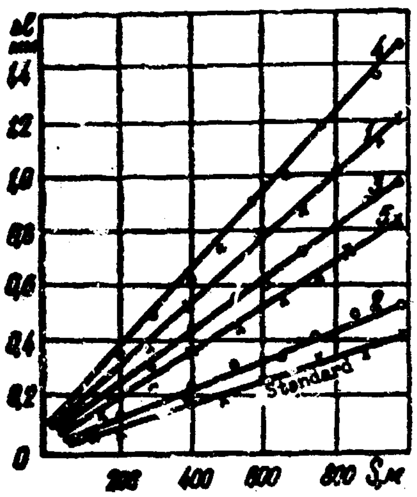

Fig. 3.

It was si...aneously that the wear of different investigated materials under identical friction conditions was different.

Comparing the curves (Figs. 2, 3) obtained as a result of the investigation we see that the greatest wear was in material No. 4, and the least - in material No. 2. Taking as unity the wear of the standard sample of organic glass, let us calculate the relative wear of the remaining materials. With friction on a dry screen the relative wear is for material No. 1 - 5.82; No. 2 - 3.11; No. 3 - 3.90; No. 4 - 12.60; No. 5 - 4.51. With friction on a screen covered with

water – for material No. 1 – 2.75; No. 2 – 1.19; No. 3 – 2.12; No. 4 – 3.49; No. 5 – 1.95. Apparently, the magnitude of wear of the investigated materials to a large degree is affected by the form and the quantitative content of filler in percent to the main polymer.

Conclusions

1. A method was developed for investigating polymeric materials for wear with friction on a screen in the presence of water.

2. The wear of investigated polymers with friction on a dry screen is considerably higher than the wear with friction on a screen covered with a layer of tap water.

3. For specific friction regimes (V = 4 m/min and q = 4.2 kgf/cm^2) the most wear resistant is material No. 2.

4. The wear resistance of the investigated materials was lower than the wear resistance of the standard material (organic glass).

5. The value of absolute wear of the investigated material with friction both on a dry screen, and also on a screen covered with a layer of tap water is considerable affected by the quality and the percentage of filler in the composition of the polymer.

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1. ORIGINATING ACTIVITY (Corporate author) Foreign Technology Division Air Force Systems Command U. S. Air Force	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE
INVESTIGATION OF STATIC FRICTION OF CAPRONE ON STEEL AT DIFFERENT TEMPERATURES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Translation

5. AUTHOR(S) (First name, middle initial, last name)
Avdeyev, D. T. and Kireyev, O. P.

6. REPORT DATE 1967	7a. TOTAL NO. OF PAGES 4	7b. NO. OF REFS 6

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 72302-78 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) FTD-MT-24-391-69 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Foreign Technology Division Wright-Patterson AFB, Ohio

13. ABSTRACT
Knowledge of the relationship of the coefficient of static friction to temperature is needed to make more accurate estimates of a series of mechanisms which operate under conditions where the surrounding temperature varies. To determine the qualitative and quantitative effect of the surrounding temperature on static friction for several friction pairs, experiments were carried out on a specially built apparatus. Essentially, the apparatus consists of a vertically mounted rod loaded with a lever device and weight from the top. Attached to the bottom of the rod is a ring-shaped sample to be tested. Bearing against the sample is a steel block supported on a mount with a ball bearing. The steel block and sample (the friction pair) are inclosed in a thermally regulated chamber. The rod mentioned above can be rotated by a pulley and falling weight, the latter being built to receive varied amounts of lead shot. The temperature of the chamber having been raised to the specified point, the sample was placed in contact with the steel for five minutes and held at constant load. The falling weight was then loaded with shot until it dropped a certain distance where a tripping device closed off the supply of shot at its source. Coefficients of static friction were computed using a formula which took into account the essential dimensions of the apparatus, the weights and the sample. Good reproducibility of tests indicates that the construction of the apparatus takes into account the basic factors influencing static friction. (AT9003634)

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UNCLASSIFIED
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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Friction Coefficient Static Test Caprone Steel Property Temperature Variation						

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Foreign Technology Division
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2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
STRUCTURE AND ANTIFRICTION PROPERTIES OF LOW-PRESSURE POLYETHYLENE DEPENDING ON TWO METHODS OF MIXING WITH MINERAL OIL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Makhin, Yu. P. and Kut'kov, A. A.

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Foreign Technology Division
Wright-Patterson AFB, Ohio

13. ABSTRACT

In structural mechanics, a comparatively new branch of polymer science, ways have been sought to obtain new materials by changing the supra-molecular structures of existing polymers by plasticizing them. Further, due to the ever increasing importance of crystalline polymers in industry, especially polyethylene, particular interest is shown in the effect of plasticizing on structural and antifriction properties. It had been assumed that the method of mixing a plasticizer with the polymer influenced the afore-mentioned properties, the present article describes tests used in examining this assumption. The initial mass was a mixture of low-pressure polyethylene polymer and spindle oil plasticizer which was treated in two different ways. In the first, the initial mass was poured into a cylinder and heated to complete fusion and then immediately transferred to the mold. In the second, the fused mass from the heated cylinder was passed through a set of screens and carefully remixed before molding. Sample structure revealed by x-ray analysis showed poor compatibility of the polymer and plasticizer where the first method was used, whereas compatibility had significantly improved in the second method. Microscopic examination of thin sections revealed that the supra-molecular structure for the first method was an open network of polyethylene with voids containing spindle oil. For the second method the structure was uniform. Orig. art. has: 5 figures. (AT9003636)

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UNCLASSIFIED
Security Classification

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Polymer Physical Property						
Polymer Rheology						
Molded Polyethylene						
Structural Analysis						
Antifraction Material						
Plasticizer						
Mineral Oil						

UNCLASSIFIED
Security Classification

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

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1. ORIGINATING ACTIVITY (Corporate author)
Foreign Technology Division
Air Force Systems Command
U. S. Air Force

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
INVESTIGATION OF THE STATIC FRICTION OF CAPRONE ON STEEL AT GREAT UNIT PRESSURES IN WATER AND WHEN DRY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Romanovskiy, A. I.

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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Foreign Technology Division
Wright-Patterson AFB, Ohio

13. ABSTRACT

Many machines and assemblies operate alternately under water and in air such as irrigation systems, flood gates and boat davits. Yet static friction in such equipment, which may operate under great unit pressures in either medium when wet or dry conditions prevail, has hardly been studied. With this in mind, the present work was initiated to examine the static friction of a No. 45 steel-Caprone B friction pair in water and when dry. In addition, an attempt was made to explain the effect of abrasives usually found in water and which collect on steel surfaces. In all, eight tests were conducted in which the caprone and steel samples had been variously prepared by machining on a lathe both dry and lubricated with water and in some instances buffed with emery cloth. Coefficients of static friction were measured on a conventional friction machine designed to maintain high, constant contact pressure and to alter the applied tangential force. It was found that the presence of water on clean steel and caprone surfaces had practically no effect on static friction. Current-carrying powders (iron) in the friction zone have little effect on a change in friction coefficient under dry conditions. Dielectric powders (glass, abrasive) together with water strongly influences the nature of the change in static friction. Orig. art. has: 2 figures.
(AT9003637)

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UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Friction Coefficient						
Sea Water						
Fresh Water						
Caprone						
Steel Property						
Air						
Test Method						
Pressure						

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Foreign Technology Division Air Force Systems Command U. S. Air Force	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE
THE INVESTIGATION OF GRAPHITOPLAST FOR FRICTION AND WEAR IN LUBRICATION WITH WATER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Kruzhilin, V. N.

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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Foreign Technology Division Wright-Patterson AFB, Ohio

13. ABSTRACT

Graphite antifriction materials possess extremely favorable properties which make them useful for machinery, especially as end face packings for pumps. The use of grafitoplast, a composition of graphite and phenolformaldehyde resin, is feasible because it is not expensive and because the manufacturing technique involved is simple compared to other graphite materials. In this investigation the coefficients of friction and wear of grafitoplast on organosilicon plastic with water lubrication were determined. The friction machine used consisted of three principal parts: the loading device, the friction pair, and the measuring equipment. Samples were ground on a cast-iron plate in advance, the grafitoplast being ground without using abrasives or grinding powders, and the plastic being ground with them. Working surfaces were carefully washed with tap water, ground to mirror finish and treated with gasoline. In friction tests it was found that the maximum wear of grafitoplast occurred in conjunction with KF-10 plastic, a composition which contained a filler of ftoroplast-4 and quartz sand, whereas the highest wear resistance was shown by a grafitoplast-KF-9 plastic friction pair, the plastic containing ftoroplast-4 as the filler. Since the samples gained weight and swelled from absorbed water, this was taken into account in determining wear. Tests of organosilicon plastics in friction on gra[illegible]ast have shown that KF-9 organosilicon plastic has the be[illegible]tifriction properties. Orig. art. has: 3 figures, 1 table.

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UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Antifriction Material						
Friction Coefficient						
Carbon Product						
Phenol Formaldehyde Resin						
Packing Material						
Friction Test						

UNCLASSIFIED

Security Classification

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* Foreign Technology Division Air Force Systems Command U. S. Air Force	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

COMPARATIVE INVESTIGATIONS OF FRICTION OF REST OF CERTAIN PLASTICS WITH LARGE SPECIFIC LOADS

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Translation

5. AUTHOR(S) *(First name, middle initial, last name)*

Kut'kov, A. A. , Avdeyev, D. T. and Romanovskiy, A. I.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 72302-78 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) FTD-MT-24-391-69 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Foreign Technology Division Wright-Patterson AFB, Ohio

13. ABSTRACT

Nowadays guides are used in flood gate construction which consist of fixed rails of stainless steel alloy and moving slides with inserts of laminated wood and plastic. The unfavorable conditions for the operation of such a friction pair (water with abrasive impurities and great unit pressures up to 400 kg/cm(superscript 2) impedes the timely closing of the gate in some cases, which might lead to damage. More often than not the gate jams due to increased static friction from prolonged static contact. So, the problem of selecting a friction pair capable of operating under such conditions with a minimum of difference between static and sliding friction coefficients becomes extremely important. With this in view, an investigation was launched of the static friction of a number of plastics paired with stainless steel under conditions approximating actual operation. The plastics tested were DSP-G wood plastic, textolite, P-68 resin and P-68 resin with powdered fillers, all having a no. 6 grade finish. A special apparatus with hydraulic press as the loading device served as the friction machine into which the plastic samples were inserted and pressed a stainless steel plate having a no. 7 grade finish. Results of the tests revealed that static friction decreases somewhat with an increase in normal load for all samples. The static friction coefficient for textolite increases more with time than other plastics. Orig. art. has: 1 figure and 2 tables. (AT9003640)

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UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Friction Coefficient						
Steel Property						
Plastic Mechanical Property						
Plastic Strength						
Static-Friction						
Dry Friction						
Friction Test						
Friction Part						
Sliding Friction						

UNCLASSIFIED
Security Classification

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1. ORIGINATING ACTIVITY (Corporate author) Foreign Technology Division Air Force Systems Command U. S. Air Force	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE
DETERMINING PRESSURE IN A HIGH POLYMERIC MASS DURING ROLLING

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Translation

5. AUTHOR(S) (First name, middle initial, last name)
Avdeyev, D. T. , Kut'kov, A. A. , Kureyko, S. M. and Romanovskiy, A.I.

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Foreign Technology Division Wright-Patterson AFB, Ohio

13. ABSTRACT
The milling process is used in a number of chemical industries to achieve ultimate uniformity of a polymer mass and additional separation of solvents. However, rolling is accompanied by strong internal and external friction wherein a great amount of heat is evolved. When considering the relationship of the amount of heat evolved to friction, it must be recognized that pressure in the mass is an important factor, a factor which can serve as a criterion of the stability of the rolling process. To determine pressure, an indirect method of measurement must be used, i. e., the measurement of a parameter functionally related to pressure, since direct measurement is unsuitable. Investigation of the rolling machine operation was made to find the parameter which would be a suitable function of pressure in the rolled mass. It was found that a suitable indirect measurement exists, namely measurement of the torsion stress moment on the drive shaft. However, other parameters, which determine the mechanical properties of the mass (rheological constants, viscosity, coefficients of internal and external friction, etc.) affect the torsion moment-pressure relationship. Therefore, a pressure calibration is required, the simplest being the rolling of copper strips and measuring pressure on the rolls from which comparisons may be made without interference from the other parameters mentioned above. Orig. art. has: 3 formulas. (AP9003642)

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UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Plastic Fabricating Machinery						
High Polymer						
Pressure						
Heat Radiation						
Internal Friction						
Friction Coefficient						
Torsion Stress						

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

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1. ORIGINATING ACTIVITY (Corporate author)
Foreign Technology Division
Air Force Systems Command
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2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
ANTIFRICTION PROPERTIES AND WEAR RESISTANCE OF POLYAMIDE RESINS WITH A GRAPHITE FILLER IN LUBRICATION WITH WATER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Translation

5. AUTHOR(S) (First name, middle initial, last name)
Imanov, M. Sh.

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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Foreign Technology Division
Wright-Patterson AFB, Ohio

13. ABSTRACT
A friction pair that works well when lubricated with water does not require the use of hard-to-get materials is extremely important in the manufacture of simple and reliable parts for submerged electric pumps. The metal-rubber pair now used quickly wears out under unstable operating conditions when the lubricant wedge of water is absent. To overcome this deficiency, a polyamide resin plastic material with graphite filler made in the NPI Laboratory of New Antifriction Materials was tested for its antifriction properties and wear resistance. The plastic paired with stainless steel and lubricated with water under conditions simulating the operation of a friction pair in a submerged electric pump. More specifically, testing was carried out under both hydrodynamic and imcomplete lubrication conditions using tap water having an overall hardness of 16.23 degrees H at 10-20 degrees centigrade in a friction machine designed for measuring deformation under load. A linear method of measuring wear and swelling (using a micrometer) was employed and antifriction properties determined by the value of the friction coefficient. It was found that the plastic test sample swelled insignificantly, and the most intensive wear of the sample was observed during the run-in period. The amount of wear of the sample when lubricated with tap water is insignificant. The steel showed practically no signs of wear. Orig. art. has: 3 figures and 1 table. (AT9003643)

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UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Friction Coefficient						
Lubrication						
Steel Property						
Antifriction Material						
Carbon Compound						
Polyamide Compound						
Underwater Equipment						
Friction Test						
Friction Part						

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

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1. ORIGINATING ACTIVITY (Corporate author) Foreign Technology Division Air Force Systems Command U. S. Air Force	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE
COMPARATIVE INVESTIGATION OF THE FRICTION OF STEEL AND PLASTIC SAMPLES UNDER THE EFFECT OF SHOCK LOADS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Translation

5. AUTHOR(S) (First name, middle initial, last name)
Avdeyev, D. T. and Litvinenko, S. N.

6. REPORT DATE 1967	7a. TOTAL NO. OF PAGES 4	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Foreign Technology Division Wright-Patterson AFB, Ohio

13. ABSTRACT

Friction in modern machines operating under sharply changing and shifting loads, which are very nearly shock loads, has hardly been studied and no test method has previously existed. Therefore, investigation of the phenomenon is of great interest. In this examination, the sliding friction of steel and plastic samples paired with steel acting under a shock load was studied. The experimental apparatus used consisted of a pendulum impact machine with a specially designed attachment having a stand on which was mounted a chuck holding the test sample, the chuck being held in position by two weighted lever arms. After the sample was held in position for a minute, the raised pendulum of the impact machine was let go which struck along the chuck. The height to which the pendulum rose after striking determined the work expended on overcoming friction. By this method the effect of increasing the normal load on the friction coefficient under shock for a steel-steel pair, dry and with boundary lubrication, was studied. Here, the lubricant used was ricinoleic acid. Results of tests showed that the friction coefficient rises with an increase in load much faster in dry friction than in boundary friction, and it was found that under identical loads the Amentons-Coulomb law is accurate only in boundary friction. The friction of plastic samples on steel was similarly studied using polyethylene with fillers. Orig. art. has: 3 figures. (AT9003644)

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UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Friction Coefficient						
Lubrication						
Steel Property						
Metal Friction						
Antifriction Material						
Polyamide Compound						
Test Method						

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Security Classification

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1. ORIGINATING ACTIVITY (Corporate author) Foreign Technology Division Air Force Systems Command U. S. Air Force	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

INVESTIGATING THE EFFECT OF CERTAIN TYPES OF CORROSION INHIBITORS AND ANTICORROSIVE COVERINGS ON THE WEAR-RESISTANCE OF A STEEL-POLYAMIDE FRICTION PAIR WITH OPERATION IN WATER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Kut'kov, A. A. and Vishnyakov, V. I.

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Foreign Technology Division Wright-Patterson AFB, Ohio

13. ABSTRACT

Existing antifriction materials such as bronze and babbit are unsuitable for working in water in a majority of cases because of wear and corrosion. Numerous investigations made on the selection and development of antifriction materials have shown high polymers and plastics based on them, particularly caprone type resins, to be particularly favorable materials. Yet it may be expected that steel-polyamide friction in water will produce intense oxidation wear of the steel. Such wear may be decreased with corrosion inhibitors or anticorrosion coatings. To test the effect of corrosion inhibitors and anticorrosion coatings on steel experimental research was conducted using a conventionally styled friction machine. Calcium bicarbonate, sodium nitrate, sodium sulfate and gallic acid were used as the inhibitors, the compounds being dissolved in a 2 percent tap-water solution. Alkali and acid oxidation, parkerization, and burnishing were selected to provide protective films. For inhibitors, each test lasted 15 hrs. In investigating anticorrosion coatings tests were stopped just as the coating wore away, a phenomenon that could be detected by the change in friction coefficient. It was found that corrosion inhibitors exert an essential influence on the wear resistance and friction properties of steel under conditions of oxidation wear. Orig. art. has: 5 figures. (AT9003645)

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Security Classification

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Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Friction Coefficient						
Lubrication						
Caprone						
Steel Property						
Antifriction Material						
Polyamide Compound						
Underwater Equipment						
Corrosion Inhibitor						
Anticorrosion Agent						
Corrosion Resistant Coating						

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1. ORIGINATING ACTIVITY *(Corporate author)*
Foreign Technology Division
Air Force Systems Command
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2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
CERTAIN QUESTIONS CONCERNING THE FRICTION OF PLASTICS BASED ON POLYAMIDE RESINS WITH A FILLER WITH WATER LUBRICATION

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Translation

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Kut'kov, A. A. and Imanov, M. Sh.

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13. ABSTRACT

The present work supplements previous research on the antifriction properties and wear resistance of subject plastic paired with stainless steel and lubricated with tap water. In this case, the antifriction properties of the plastic paired with stainless steel and with bronze were examined. In addition, empirical formulas obtained by mathematical treatment of experimental data, formulas that can be used in engineering computations. It was found that the antifriction properties of polyamide resins with a filler in friction on steel and bronze when lubricated with tap water were acceptable. The time for wearing-in of the plastic was determined graphically from curves showing the relationship of friction coefficient to time of operation. In the case of a steel-plastic pair, tests showed that it took 5 hrs at a unit pressure of 3.5 kg/cm(superscript 2) (determined from the curve's horizontal asymtote). Empirical formulas for finding the relation of friction coefficient to unit pressure and for finding the relation of swelling to time were shown. Orig. art. has: 4 figures and 7 formulas. (AT9003646)

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	ROLE	WT	ROLE	WT	ROLE	WT
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Friction Test						
Friction Part						
Bronze						
Mathematical Method						
Swelling Property						

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13. ABSTRACT

Due to the widespread use of plastic parts in machinery, the problem of their wear resistance is of great interest. Since in this examination the tests were to be made in a water medium, existing methods of abrasion wear could not be used. A new method was therefore developed in which an apparatus, a prototype of M. M. Krushchov's Kh4-B machine, was used containing a metal screen as the wearing surface on which a layer of tap water could be poured. Several types of high polymers with varying percentages of filler served as the materials under investigation, the first being polyamides with graphite filler. Wear of the samples was determined from loss of material from sliding friction on the screen when dry and when covered by a layer of tap water. For comparative purposes, tests were made under the same conditions using plexiglas [lucite] as a standard. It was found that the wear of the polymers in friction on a dry screen is significantly greater than wear when the screen is covered with a layer of tap water. This could be explained as being due to a rise in temperature in the first instance and the lack of it in the second, where there is constant water cooling of the rubbing surfaces. The most wear resistant material was one designated No. [illegible] in a series of five polymers containing increasing amounts of filler; however, the wear resistance of all these materials was lower than that of plexiglas, the standard material. (AT9003647)

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Antifriction Material						
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Carbon Compound						
Friction Test						
Dry Friction						
Sliding Friction						
Fluid Friction						